INDOOR PLANT MAINTENANCE SYSTEM (IPMS)

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Abstract – This paper describes the design and implementation of an automated indoor plant maintenance system (IPMS) intended as a consumer product. It is a project conducted as part of the Senior Design course at the University of Central Florida. The product will provide plant owners with a convenient means of maintaining their indoor plants when they are absent for extended periods of time. The engineering requirements call for sensors which monitor the environment around the plant, controls which apply resources as needed, a wireless remote user interface to set the operating parameters, and intelligence to manage the system without constant human interaction. It combines inexpensive hardware components and custom software in a small package that is easily deployed, plus a web-based interface. From a marketing perspective, it is designed to be low cost and easy to use.

Keywords – Automation, plants, plant care, wireless, Wi-Fi, Bluetooth, remote management, Electrical Engineering, Senior Design

I. INTRODUCTION

People enjoy family vacations. Many people neglect their home plants as a result. To keep the soil moist, self-watering plants soak the bowl's bottom. Neither design tracks how much water or light each plant gets. People also estimate or guess how much water to put in the pot before leaving home. You could also hire someone to water your plants. Most people ignore the plant. Some people may attempt to install their irrigation system using a YouTube tutorial.

IPM will fix it. Global access to data is the goal of the IPMS. It focuses on small to medium-sized plants purchased in the US. Sensors in the IPMS hardware will gather data on the plant's surroundings and display it via Wi-Fi. Using any internet-capable device, IPMS will be accessible worldwide via the Internet. This improves IPMS. To protect the circuitry from being damaged, the circuit board will be waterproof. All-in-one plant care tool Plant health can be managed from anywhere. Unwatering the plants? It's online. That eases plant care.

A. Project motivation

Plants are popular in many homes. When not in their natural habitat, plants require constant care. They require sunlight and water even indoors. No one is home to care for the plant. As an example, plants will suffer if a homeowner is away on business or vacation. People will often ask a friend or family member to water the plants, so they don't wilt. Some create a do-it-yourself (DIY) watering system for plants using household items such as a water bottle with a thin tube in the soil. This solution is incompatible with plant care. The plant may be overfed or underfed when DIY kits are used to feed it. An intruder may overwater the plant and DIY kit. This is because plants have different needs. Some plants only need water every other day, while others need it constantly. IPMS is the proposed solution.

This system will take care of indoor plants while the owner is away. In response, the Indoor Plant Monitoring System would water the soil as needed. The IPMS will be simple to use. Using the IPMS, you can tell how much light the plant receives daily and how much water it needs. Keep it hydrated and lit when no one is home. Each plant's water level will be monitored by an app that allows the homeowner to turn off or manually add more water. This allows the owner to avoid overwatering. This is the only indoor plant monitoring system that allows remote interaction. It has thousands of positive online reviews. As the pot lowers the plant into the cup of water, the soil soaks it up. The issue is that it may not reach short roots, preventing even water distribution. Soil moisture would be applied by gravity to the top of the soil.

B. System Specifications

Sr.No.	Description
01	No need for the user to manually keep on checking the plants' health
02	Automatically water the plants when the owner is not present
03	The power consumption of a wireless sensor network should be less so that it can be used for a long period.
04	The user interacts with the android application and the sensors fixed around the plants will update the current condition of the plant environment.
05	Precision is providing the environmental condition of the plant.
06	Sensors obtain ambient temperature, ambient humidity, soil moisture and illuminance them to the cloud which is then displayed on the UI on the user Android device.
07	If the user is facing Internet problems, he/she can easily access using Bluetooth.
08	The application should have an easy-to-use interface and present data with minimal latency.

Table 01: System Specifications

C. House of Quality:

The House of Quality Analysis shown in Figure 01 estimates the marketing-engineering relationship. It guides the project's design and performance requirements. The marketing requirements are the anticipated needs of our product's users.

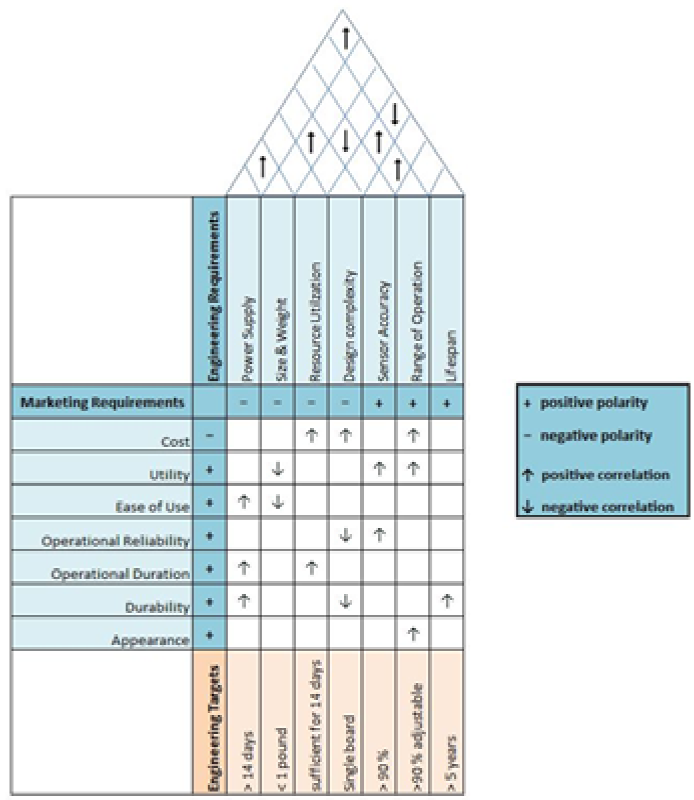

Figure 01: House of Quality

D. Hardware Block Diagram

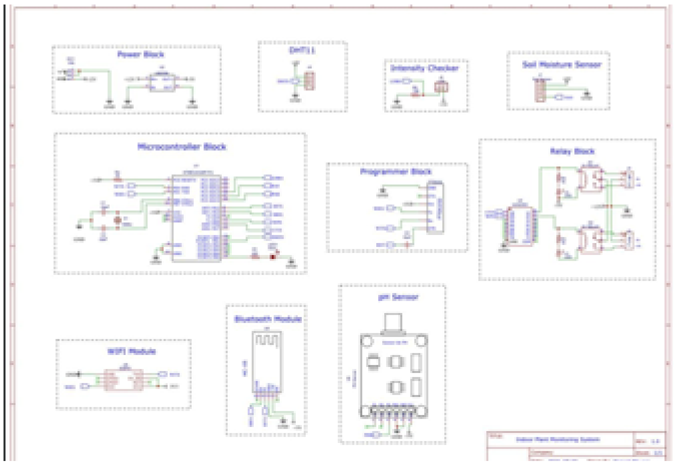

Figure 02: Hardware Block Diagram

E. Software Block Diagram

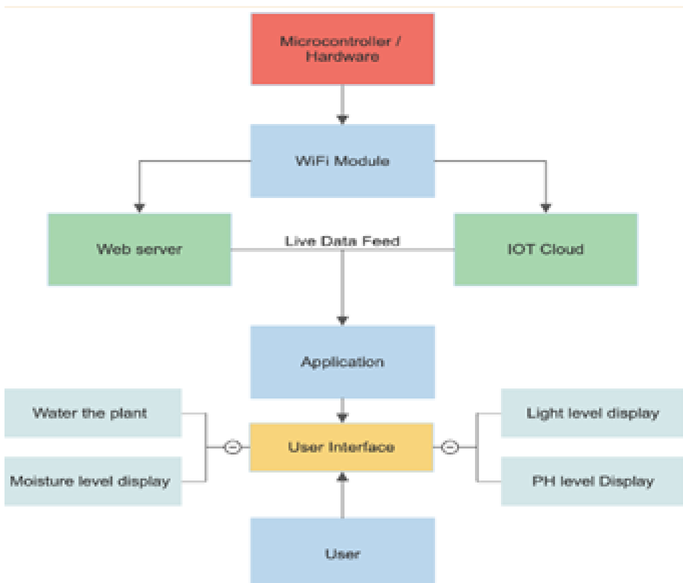

Figure 03: Software Block Diagram

F. Hardware Specifications

Module	**Specification**
ESP8266 WIFI Module	Power Supply: 3.3V Current Consumption: 100mA I/O Voltage: 3.6V I/O Source Current: 12mA Flash Memory: 512KB
HC-05 Bluetooth Module	Supply Voltage: 3.3-5V Working Current: 30mA Operating Range: 10 Meters Support Baud Rate: 9600,19200,38400,57600,115200 Dimensions(L x W x H) : 28mm x 15mm x 2.35mm
Soil Moisture Sensor	Operating Voltage: 3.3V-5V Operating Current: 15mA Output Digital: 0V-5V Output Analog: 0V-5V PCB Dimension: 3.2cm x 1.4cm

pH Sensor	Supply Voltage: 5V Current: 5-10mA Working Temperature: 10-50 Degree Centigrade Probe Response Time: <2 Minutes Noise: <0.5 mV
DHT11 Sensor	Working Voltage: 3.3-5V Measurement Range: 20-95% RH ; 0-50 Degree Centigrade Resolution: 8Bit(Temperature) , 8Bit(Humidity) Compatible Interface: 2.54 3-Pin Interface
Buck converter lm2596	Input voltage: 3-40V Output voltage: 1.5-35V(Adjustable) Output current Rated current is 2A, maximum 3A (Additional heatsink is required) Switching Frequency: 150KHz Operating temperature Industrial grade (-40 to +85) Conversion efficiency: 92%(highest) Load Regulation: ± 0.5% Voltage Regulation : ± 0.5%
1N5408 Diode	Forward Current: 3A Forward Voltage: 1.2V Operating Temperature Range: -65-150 Degree Centigrade Number of Pins: 2
1N4007 Diode	Forward Current: 1A Forward Voltage: 1.1V Operating Temperature Range: -65-150 Degree Centigrade Number of Pins: 2

Table 02: Hardware Specifications

II. HARDWARE DESCRIPTION

A. Microcontroller

The microcontroller is the project's brain. It runs the whole thing. Its main job is to receive, process, and output data. Microcontrollers have I/O. Digital and analog data can be written. Low-power microcontroller with EPROM non-volatile memory. Wi-Fi and Bluetooth modules must be able to send and receive data from the UV lamp, pump, LDR, and PH sensor. The MCU must also be able to control the pump's speed and the UV lamp's brightness and intensity to create the ideal indoor plant growth environment. All of the components work together to regulate the environment for plant growth in this project. Need a low-cost MCU with a large number of digital and analog pins that can produce desired outputs on a budget. This project considered the ATMEL ATmega328 and ATmega168. These circuits use the microcontroller. The buses are also interconnected. Bus systems in such a circuit serve various functions. The digital and others perform system functions. The system has parallel buses. In this case, digital systems such as the PC's ROM control the bus system to transfer data.

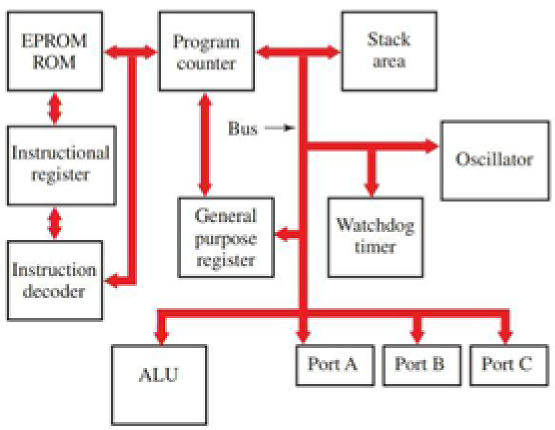

Figure 04: Microcontroller Function

B. Program counter and Stack pointer

The stack pointer prevents interruptions when one processor completes a task. If there is a problem, the system will be disrupted. In this case, the entire system is designed to work in multiple directions and efficiently. The processor can perform other tasks when free. They don't do what the disruption does. This is how the program counter works.

ATmega 328	ATmega 168
The ATMEL ATmega328 is a user-friendly 8-bit Microcontroller. It has a 2KB SRAM and a 32KB flash memory. 1KB of EEPROM and 13 digital I/O pins (EEPROM). One of Arduino's features is an EEPROM for data storage. $10 for 10 ATmega328 on AliExpress The Arduino IDE can be used to program it. The ATMega-328 has a variety of performance specifications.	ATmega 168 is the 2^{nd} option. It also has 512 byte EEPROM. 2.7-5.5V. $1.2-$1.3 per piece 16MHz crystal oscillator board. It's got a 32-pin AVR. CMOS and IS. This chip is controlled by a 16K memory. From 1.8 to 5.5 V in embedded systems or automation projects. Other programming systems can benefit from it. It is a single-chip system with multiple functions. After explaining the module system, it is now clear how the chip is used. It is a real application system that uses multiple processors to perform work efficiently. I love how it protects the chip with a hardcover.

Table 03: Microcontroller Comparison

C. Soil Moisture Sensor

The soil moisture sensor in this project measures soil moisture. This is done to keep the soil moist enough for plant growth.

Soil resistance sensors:

It uses resistance. It sends a current through the soil and measures its resistance to current. More water means more current and less resistance to current flow. The sensor is easy to use.

Soil capacitance sensors:

This sensor measures soil moisture. It is corrosion-resistant and long-lasting. Moisture is measured by capacitance. Each plate is separated by a dielectric medium. A microcontroller can also read the analog voltage signal.

Feature	Resistive	Capacitive
Input Voltage	3.3 – 5.5V DC	3.3 – 5.5V

Output Voltage	0 – 5V	0 – 3V
Input Current	15mA	5mA
Price	$0.74	$0.63

Table 04: Comparison of Soil Moisture Sensors

D. Wi-Fi Modules

A two-module data transfer project has two options: a Wi-Fi module and a Bluetooth module for when the Wi-Fi module fails. The microcontroller sends data to the smartphone app via a wireless module. The ESP-01 and ESP-05 are two popular Wi-Fi modules. For data transmission over Wi-Fi, the Wi-Fi Module is vital. Microcontroller-Wi-Fi network host Pre-programming the ESP8266 module with the set fire ware gives you the best ability to work in a low-cost board with a large community. This Wi-Fi module can store and send data to other devices. Information fountains for the ESP8266 module are available from a community

Feature	**ESP – 01**	**ESP – 05**
GPIO pins	02	0
ADC	No	No
Antenna	PCB	PCB
Breadboard Friendly	Medium	Good
Voltage	3.3V	3.3V
Price	$3	$3

Table 05: Comparison of Wi-Fi modules

E. PH Sensor

A PH sensor measures a substance's acidity or alkalinity. No. 1 to 14 (PH) (–log10 [H+]) is the hydrogen ion's negative algorithm. H ion activity is measured in practice. How to use pH in a well-sequenced. PH is the best potentiometer. You can't get PH readings without it! The reference electrodes and sensing have been measured. The Ph slope is 0mV and 59mV. As a result, PH will change in all ways. Nernst's equation explains it:

Feature	**Specification**
Input Power	5V
Module Size	43mm*32mm
PH measuring	0 – 14 PH
Temperature Measuring	0 – 60 Degrees
PH interface	2.0
Gain Adjustment	Potentiometer

Table 06: PH meter Specifications

F. PH electrode dimensions

Finding a low-cost PH metre and other parameters is difficult. We used an analog metre to measure the PH scale of the substance. An LED power indicator, a BNC connector, and a PH2.0 interface for sensing the substance's PH are all included. Connections: BNC connector for pH sensor, Arduino analog input for the interface. To get the values, the pre-programmed module will do so. We must regularly calibrate the PH value with the standard solution to ensure accuracy.

Voltage (mV)	PH value	Voltage (mV)	PH Value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

Table 07: PH electrodes characteristic

G. Relays

Relays will control the UV lamp and pump. A high impedance coil will limit draw on the activation circuit, yet provide maximum flexibility in choosing contacts suitable for the application.

I. OUTPUT

Software Structure:

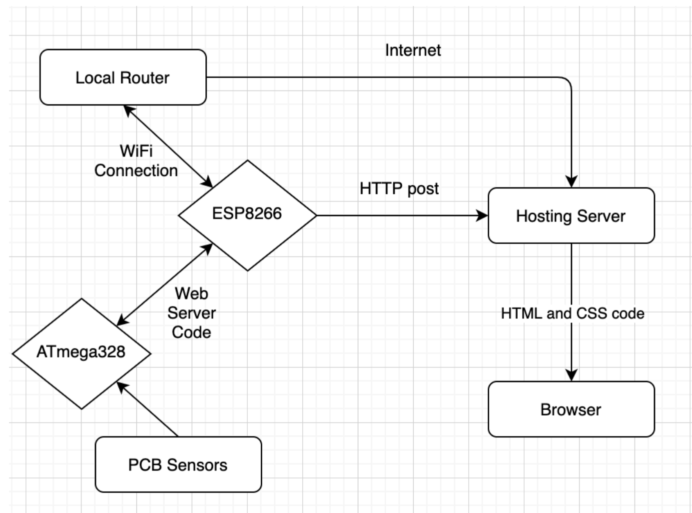

Figure 05: Web Server Structure

The software for the IPMS is structured as shown in the figure to the left. The two main software components are the ATmega328 and the ESP8266. The Atmega is reading information from the PCB sensors and sending them to the ESP8266 WiFi module via the Web server code that we uploaded to the ATmega328.

From the ESP8266 will connect to a local router using a WiFi connection. The ESP8266 then Creates a web server and starts making HTTP requests to the Hosting server. Using HTML code that we will print to the web server, we can create the web page that we can visualize from the web browser.

Application:

- Display - The Web page will display all information related to the plants overall health including:

- ○ PH Level
- ○ Temperature around the Plant
- ○ Moisture level in the soil of plant
- Control - The Web page will make suggestions based on the current levels of PH, Temperature and soil moisture. The following suggestions can be made:
    - ○ Recommendation: Reduce or Raise the room temp
    - ○ Recommendation: Use water with a higher/lower pH
    - ○ Recommendation: Water the plant (soil moisture low)
- Actions - The web page will have buttons written in HTML and CSS so that the user can carry out certain tasks within the IPMS. Such as:
    - ○ Activate water pump: Water the plant
    - ○ Refresh Display settings and view recent plant health information.

H. Software testing

For this section of testing we want to make sure all components properly connect with each other and are able to communicate with the microcontroller. This includes the entire Internet of Things. In this section we will show our testing methods for the Sensors, Microcontroller and ESP8266.

Components for Testing:

- ATmega328
    - ○ ATmega328 should be able to be programmed using the Arduino uno as an ISP.
- DHT11 Temperature Sensor
    - ○ DHT11 temperature sensors should be able to feed the ATmega328 with data.
- PH Sensor
    - ○ The PH sensor should be able to share data to the microcontroller.
- Soil Moisture Sensor
    - ○ Moisture Sensor should be able to feed the ATmega with data from the plant's soil.
- ESP8266
    - ○ WiFi Module should be able to host Web Server and show up in a web browser as a valid address.

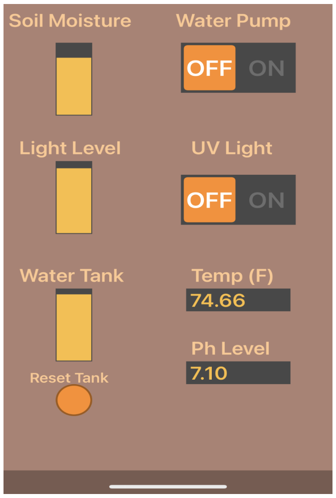

Figure 06: User Interface Design

I. User Interface

The user interface is shown in figure 6. Features have been added so that the user is able to gauge the plants health in some sort of visual scale. The soil moisture level will tell the user if the plant needs to be watered. the user can then activate the water pump which is able to pump a gallon of water in a minute 30 seconds or 90 seconds.

The water tank level is measured in respect to the time it taked to pump a gallon of water. When the tank gets low the user should then check the tank level to make sure there is sufficient water. When the user refills the tank to about a gallon of water they should then reset the tank level so that the software can reset the watertank level.

the light level is also measured on a scale. The light level is highest when in direct sunlight. When the light level gets to low the user than can turn the UV light switch to the ON position.

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